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I. Part of a Letter from Mr Anthony van Leuwenhoek, concerning Worms observ'd in Sheeps Livers and Pasture Grounds. Delf, Nov. 3. 1703.

**T**HIS serves to communicate to you my slender Observations concerning the *Animalcula* that are almost always found in Waters, and also sometimes upon Land.

In the Summer of the Year 1702. we had not Rain enough to cover even the lowest parts of the Meadows adjacent to our City; insomuch, that none of the Sheep of that year drank of the Waters that used to stagnate on the said Meadows, which when it happens (according to the opinion of our Butchers) produces a certain sort of Worms called *Bottiens* in their Livers, whereof we have formerly spoken more than once. Notwithstanding which, I was informed that some of the Sheep of those Pastures had their Livers infected with such like Worms; this made me conjecture that the above-mentioned Distemper in the Livers of the Sheep must proceed from some other cause than their drinking the said Waters.

I caused a Butcher therefore, who was Owner of one of these Meadows (and who had also informed me that the Sheep which he turned into that Ground were mightily pester'd with Worms in their Livers) to cut me two pieces of Greensod from thence, to the end I might try whether I could find any such Worms in them.

This Land he told me was so high, that it was never wholly under Water in Winter time, but the Ditches about it were so full, that they were in a manner level with the Land, and some of the lowermost parts of the same,

same, when it rained much, were a short time covered.

I narrowly sifted those two pieces of the Earth, but could find no *Animalcula* in them that any way resembl'd the Worms in the Sheeps Livers.

From hence I infer, that the *Animalcula* that are found not only in Sheeps but in Cows Livers too, must not be sought for in those Waters that stagnate upon the Land, (as I formerly thought, and the Butchers also are of the same opinion) but that we must seek them in the Land it self; which being thoroughly wet or soakt, they ascend to the superficies of it, because the common Water being not natural to them, they cannot live in it; and thus lurking in the Gras they are swallowed by the Cows and Sheep, and such as escape their Teeth are conveyed into their Stomachs and Bowels, and insinuate themselves even into the Liver.

I have been often told that the Cattel which feeds in Siltagig Grounds are free from this Disease of Worms, but being informed that the said kind of Ground is very low, and lies under Water the most part of the Winter, I gave the Butcher these Reasons :

Why Kine and Sheep that feed in high Clay grounds are troubled with Worms in their Livers, and those in low Grounds are free, is, only because the low Grounds lie all the Winter under Water; for tho such like Worms may be found in some of the low Lands, yet as soon as they are overwhelm'd with Water, those Worms, abhorring the Water, die immediately.

To confirm my reasoning, I took a Glas Tube, which at the upper end was about an Inch wide, and above a Foot in length, I put into it a little piece of the above-mentioned Earth near 5 Inches long, but so narrow, and the Gras about it clipt so close, that it would easily go into the Tube without pressing, and then poured upon it boild Water, which had stood till it was cold.

Presently after I perceiv'd that several very small and long

long white Worms came out of the Earth, which reaching and incurvating their bodies, subsided leisurely to the bottom of the Tube, none of them being able to emerge to the superficies, whence I concluded that they could not live in the Water ; and in effect, after they had lain 24 hours in the bottom of the Glass, I found they were all dead.

It seem'd to me also that these white Worms consisted of several sizes or magnitudes, and that they could not be the Offspring of our common Worms, because they were much longer, in proportion to their bigness.

I saw likewise a common Worm creeping out of the abovesaid Earth, which leisurely subsided and remained at the bottom of the Tube with little or no motion, and the next day it was dead.

As for those small *Animalcula* that came out of the Earth, and swam about the Water, they were of so many several sorts and sizes, that the description of them would take up too much room, besides some of these *Animalcula* were so exceeding small, that I could not perceive what figure they were of, tho I viewed them very nicely and very frequently, nay, tho I shifted the Earth and Water three times.

Now that these *Animalcula* may be call'd Water-worms, tho they are found in the dryest part of the Earth, appears from their living so well in the Tube filled with Water, in which, tho I observ'd them day after day, I found no difference in them, save that they were encrease in number, and besides I have met with several of them in common Water.

In these Observations I discovered a few particles of Sand mixt with Clay, the sides of which appear'd as if they had been broken or grated off from Stones, and some of them were so very small, that above a thousand of them together did not exceed the magnitude of a single grain of common Sand that is us'd in Scouring, &c.

I went another time into one of the Meadows near our Town, it consisted of a good Clay Earth, and was as high as any of those about us; I dug out a little bit of the said Earth, about the bigness of a Crown piece, which was covered with Clover-grass, short and fine; I imagined I should find in the top of it some living Creatures, because I had formerly found in the rotten wood of a Willow Tree, and in another rotten Plank that had lain in the open Air, some of those *Animalcula* which are usually found in the Water.

When I came home I clipt away the Grass from the Earth or Clay, and put the top of it in a clean Glass Tube about as big as a Childs Finger, and pour'd upon it boil'd Rain Water after it was cold, and having shaken that Earth and Water well together, the Water was so thick and troubl'd, that I could perceive none of the *Animalcula* therein, tho there were a great many in it.

But after the said Water had stood about half an hour in the Tube, I could perceive several *Animalcula* creeping up the sides of it, and others swimming about the Water.

This Water having stood several hours, and acquired a little more clearness, I saw two particular *Animalcula* that came very near in Figure to those that produce little Wheels out of their Bodies, only instead of such Wheels they protruded a Horny part out of their Body, which they sometimes drew in, and then thrust out again; there was also one *Animalcolum* that put out two Wheels, and just by I perceived two other sorts of *Animalcula*, but immediately lost sight of them again; from whence I concluded, that so much Water was not natural to them, and therefore they were dead; and after that the Water had stood three days upon the Clay, I saw several *Animalcula* that were four times as long and as thick clinging to the sides of the Glass without any motion, tho they stirred about briskly at the first.

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I took another Glass Tube, and put into it a little of the same Earth which I handled very tenderly, pouring upon it some of the boiled Water as before without shaking it at all, that the *Animalcula* might emerge the better, and after an hours time I saw above twenty *Animalcula* swimming, whereas in the first I could perceive none ; and one of them thrust Wheels out of his Body.

Now it will appear strange to some, that these *Animalcula*, which usually and naturally swim in the Water, should be found in Earth that has not been moisten'd by Rain or otherwise in several weeks ; but they must be informed, as I have often found by experience, that several sorts of very small *Animalcula* are to be met with in Rain water, and especially in the Gutters on the tops of Houses ; for I have taken some of the slime or dirt of those Gutters after they have been dry above a year, and diluted the same in boiled Water after it was cold, whereupon I saw several *Animalcula* swimming, and some of them being up folded almost in a Globular Figure, extended their Body leisurely, and then swam about the Water.

If it be objected, how comes it to pass that these *Animalcula* that are meerly aquatil should be found on the Land several rods distant from any Ditch ; I answer, I conceive this to happen after the following manner.

We have often found in a Storm, that the Water has been so furiously driven against the sides of the Ditches, and the parts of such Water so minutely divided, that not only several of its smaller Particles have been carried a great way into the Land by the strong Wind, but some of them also thrusst up, or attracted even into the Clouds ; and I am confirmed in this opinion by the following instance : I stood one time to observe with what force, and how great a distance a Bleecher cast Water with his Scoop out of a Ditch upon his Linnen that was spread over the Meadow, whereby many of the parts of the Water were

were so divided, that they never fell to the Earth, but were exhaled up into the Clouds.

In the said small Particles of Water are conveyed the above-mentioned small *Animalcula* far up into the Land, and when the Ground becomes dry, they contract themselves into an oval Figure, and the Pores of their Skin are so well clos'd, that they do not perspire at all, whereby they preserve themselves till it Rains, upon which they open their Bodies and enjoy the moisture. And thus, in my poor opinion, it happens that we find these *Animalcula* in every Meadow of our Country, none of which are very remote from the Sea or Water Canals.

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## II. Solutio Problematis.

*A Clariss. viro D. Jo. Bernoulli in Diario Gallico*

*Febr. 1403. Propositi.*

*Quam D. G. Cheynæo communicavit Jo. Craig.*

**P**roblema. Propositæ Curvæ Geometricæ alias innumeræ Longitudine æquales invenire.

*Solutio.* Sint  $w$ ,  $s$ , co-ordinatæ Curvæ datæ; & Curvæ quæsitæ sint co-ordinatæ  $x$ ,  $y$ : tum ex conditione Problematis erit  $dw^2 + ds^2 = dx^2 + dy^2$ . Ponatur  $dx = dw - m dz$ , unde erit  $dy = \sqrt{ds^2 + 2m dw dz - m^2 dz^2}$ ; in hac pro  $ds$  substituatur ejus valor per  $w$ ,  $dw$  & determinatas expressus: & pro  $dz$  assumatur talis valor ex  $w$ ,  $dw$  & determinatis compositus, ut valores quantitatum  $dx$ ,  $dy$  sint summabiles: Et sic habentur  $x$  ac  $y$  Co-ordinatæ Curvæ quæsitæ. Q. E. J.

*Exemplum 1.* Invenire Curvam æqualem Lineæ Parabolicæ. Sit  $z$  a latus rectum Parabolæ; adeoq;  $z$  a  $s$

Aaaaaaaa 2

$ds$